



NATIONAL RADIO ASTRONOMY OBSERVATORY

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of)	
)	
Unlicensed Operation in the TV Broadcast Bands)	ET Docket No. 04-186
)	
Additional Spectrum for Unlicensed Devices)	
Below 900 MHz and in the 3 GHz Band)	ET Docket No. 02-380

Comments of the
National Radio Astronomy Observatory
Charlottesville, VA 22903

I. Introduction, Background and Summary of Concerns

1. The National Radio Astronomy Observatory (NRAO) is pleased to provide comments in response to the Commission's Notice of Proposed Rule Making FCC 04-113 (hereinafter "The NPRM") "Unlicensed Operation in the TV Broadcast Bands" (ET Docket No. 04-186) and "Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band" (ET Docket No. 02-380).

2. The NRAO (<http://www.nrao.edu>) is a publicly-funded institution operated by Associated Universities, Inc., (<http://www.aui.edu>) under a cooperative agreement with the National Science Foundation. It is one of the largest astronomical observatories in the world, and by far the largest dedicated solely to observing at radio wavelengths. The NRAO currently operates the Robert C. Byrd Green Bank Telescope (GBT) in Green Bank, West Virginia, the Very Large Array (VLA) in Socorro, New Mexico, and the Very Long Baseline Array (VLBA), an array of ten antennas spread across the United States from Hawaii to St. Croix. The NRAO is also the North American partner for construction of ALMA (Atacama Large Millimeter-wave Array; <http://www.alma.nrao.edu>), an international facility sited in northern Chile comprising 64+ millimeter/submillimeter-wave antennas designed to observe up to 1 THz.

3. The NRAO supports much of the basic research in radio astronomy which is conducted world-wide because its instruments are made freely available to all researchers whose proposals pass the peer-review process. It provides state-of-the-art instrumentation at its telescopes and maintains a community-based development program which solicits instrumentation from researchers working throughout North America, including Canada and Mexico. In striving to be a responsible steward for both its discipline and the public funds entrusted to it, the Observatory acts whenever possible to support and encourage the practice of radio astronomy. Its comments in this instance are an example of that support.

4. The Commission's proposal to allow unlicensed use of the TV broadcast bands at fundamental frequencies ranging from 76 to 700 MHz, or up to several gigahertz including low-order harmonic out of band emissions, presents a very wide range of distinct issues and concerns for radio astronomy. Propagation effects, thresholds for harmful interference, instrument characteristics and the nature of scientific inquiry and technique all vary widely. Moreover, the Commission has proposed to prescribe in only very broad terms the parameters of the devices which might be allowed. Consistent with the Commission's broadly-based approach, NRAO's Comment draws attention to those areas of most general and far-reaching concern (Sections II - VII). The concluding Section (VIII) is a summary of recommendations for courses of future action which, respecting the Commission's charge to increase spectrum efficiency, would support the NRAO in

its continuing efforts to work productively from the remote locations of its stations.

II. Considerations of Spectrum

5. The channel 37 spectrum band at 608-614 MHz occurs within an otherwise continuous spectral region (470-806 MHz) assigned to the broadcast TV service. A protected radio astronomy band at 608 - 614 MHz occupies the spectrum which would otherwise have been used for channel 37, sharing and coordinating with the medical telemetry service. The spectrum band for channel 37 is therefore not assigned to the broadcast TV service (also generally true worldwide). The NRAO gratefully acknowledges and fully supports the Commissions's proposal, at para. 33 of the NPRM, not to assign channel 37 to unlicensed devices in the future.

6. To prevent interference to the radio astronomy band at 608-614 MHz, the Commission has, to date, generally acceded to NRAO requests not to assign broadcast licenses for channels 36 and 38 near stations of the radio astronomy service. The potential for harmful interference to the radio astronomy band at 608-614 MHz would be greatly reduced if use of channels 36 and 38 by unlicensed devices were also restricted, at least near radio astronomy stations. Use of coordination distances for adjacent channels is of course fundamental to the rules governing the broadcast TV service, and application of coordination distances to channels adjacent to the protected radio astronomy band observes the principle that all services deserve equal protection under the rules.

7. The protected radio astronomy band at 74 MHz occurs in a narrower 4 MHz gap in an otherwise contiguous set of broadcast TV assignments occupying the region 54-88 MHz (channels 2-4 and 5-6, separated by the 4 MHz gap). The Commission has already proposed not to allow unlicensed operation on channel 4 (NPRM at 33 and 34), which we most strongly endorse. Protection of the 74 MHz radio astronomy band would be greatly aided by restricting unlicensed use of channel 5, at least near stations of the radio astronomy service: in this regard, the 74 MHz band between channels 4 and 5 resembles that at 608-614 MHz discussed at para. 6 here. There are additional prospects for interference from unlicensed use of channel 5 spectrum, whose second and fourth harmonics overlap protected radio astronomy bands as discussed in the succeeding paragraph (8).

8. There are a substantial number of coincidences between harmonics of the broadcast band frequency ranges and higher-lying protected bands of the radio astronomy service. Noting that channels 52-69 will not in the future be allocated to unlicensed devices under the terms of the NPRM, there are the following lower-order harmonic coincidences;

Band Center (MHz)	Channel	Order of Harmonic
151.5	5	2
325	5	4
408	11,12,6	2,2,5
611	11,12	3,3
1413	52,53,54,14	2,2,2,3
1665	27,28	3,3
2695	47,48	4,4

The potential for harmful interference in the radio astronomy bands is particularly great in these cases.

9. In addition to the protected bands, the NRAO also contemplates the introduction of unlicensed devices into the National Radio Quiet Zone where, for the licensed services, there exist coordination requirements based on thresholds for harmful interference over the entire spectral region occupied by the broadcast TV service and its low-order harmonics. This is a particular

example of an issue with which the Commission and its respondents have recently wrestled, namely the proposed uses of smart and/or higher-power unlicensed devices and services in rural areas.

III. Undefined Characteristics of Unlicensed Uses

10. Although the Commission clearly foresees certain types of uses, such as WISP deployment in the fixed/access category (inter alia, at paras 1, 2, 10, 18, and 25), the proposed unlicensed uses are subject only to restrictions on total radiated power and gain (and/or some combination of these) and to a proportional limit on out of band emissions, i.e. out-of-band emissions at -20dB with respect to those in-band, taken over an appropriate spectral interval. Thus the maximum spectral power density (power/Hz) is not actually specified by the proposed rule making, either in-band or out of band. However, thresholds for harmful interference to radio astronomy are generally specified in terms of power flux density (watt/m²/Hz).

IV. Separation Distances Required to Avoid Harmful Interference

11. The Commission is proposing to allow unlicensed operation of two basic categories of devices (personal/portable; fixed/access) over a range of frequencies from 76 to 700 MHz with power and gain given for each type of device, independent of frequency. Devices operating in the upper portions of this range will have low-order harmonics extending up to several GHz, subject to the Commission's proposed extension of its existing rules for out-of-band emissions. Thresholds for interference detrimental to the operations of the radio astronomy service are commonly calculated assuming a receiving antenna gain of 0 dBi, corresponding to the area of an isotropic radiator (wavelength²/4pi). This area varies by 29.1 dB (a factor of approximately 815) over the range 70-2000 MHz. Propagation characteristics also vary widely over such a wide range of frequency, as do the emissions limits which correspond to harmful interference. Thus, there is no single calculation of a separation distance which suffices to characterize the interaction of unlicensed and licensed uses in the present context.

12. As noted here at para. 10, the power spectral density and other characteristics of proposed unlicensed operations are largely unspecified, which further complicates the calculation of separation distances to avoid harmful interference to the radio astronomy service. However, for many plausible circumstances it follows that large separation distances must be maintained. Thus, the National Academy of Sciences Comment on the Commission's NOI in this docket derived separation distances of 50-400 km when discussing whether to allow unlicensed use of channel 37, with the smaller distances corresponding to antennas of the NRAO's VLBA and the greater distances for the large single dish instruments of NAIC in Puerto Rico (Arecibo), and that of the NRAO in Green Bank, W. VA. Both the National Radio Quiet Zone and the island of Puerto Rico are, of course, substantially smaller than the nominal separation distances for their hosted instruments.

13. In the National Radio Quiet Zone, threshold levels for interference detrimental to operations at the Observatory have been specified for all frequencies of present concern: licensed operations are obliged to coordinate with the NRAO to ensure that these thresholds are respected. The Quiet Zone thresholds for spectrum not specifically mentioned in, for example, ITU-R RA. 769 and/or footnotes of the US Frequency Allocation Tables, are somewhat less restrictive. However, nominal separation distances of several tens of km may still be derived for plausible assumptions regarding the emission mask of unlicensed devices considered in the NPRM. Thus, the NRAO believes that interference detrimental to its operations will occur if the proposed unlicensed devices are allowed to operate within the National Radio Quiet Zone.

V. Fixed/Access Use Should Coordinate with Radio Astronomy and/or Avoid Use of Certain Channels

14. The Commission contemplates a division of the newly-proposed unlicensed use into two types, one of which, fixed/access, could be subject to higher emissions limits (1W for gain up to 6 dBi) and to a range of restrictions on installation and operations, such as registration in a database (NPRM at 25-28). According to the NPRM, such devices will "generally" be operated from a fixed location. At para. 28 the NPRM specifically requests comments on whether additional requirements would be appropriate for these operations. The NRAO recognizes that such uses could form an important component of the National Information Infrastructure. The NRAO requests, however, that these fixed/access operations be subject to coordination requirements, akin to those which exist for licensed services, within the National Radio Quiet Zone, and more generally, in proximity to radio astronomy stations. Coordination is also requested to cover the case that a previously notified and coordinated fixed/access station is to be moved.

15. Such coordination requirements have proved to be effective means of avoiding harmful interference and will in the vast majority of cases amount to no more than a notification of the intended installation. Such coordination would pay particular attention to the use of channels 5, 6, 11, 12, 14, 27, 28, 36, and 38 (or 52-54) which are especially likely to cause harmful interference, as noted in Section II here. In the absence of a coordination requirement, the NRAO requests that fixed/access installations not use these channels in the NRQZ and near stations of the radio astronomy service which are registered to operate at frequencies below 3 GHz (which includes all stations operated by the NRAO).

16. The NRAO strongly endorses the Commission's proposed registration requirements for fixed/access use.

VI. Control Technologies for Personal/Portable Devices

17. The NRAO believes that the utility of wireless control signals is circumscribed by an intrinsic asymmetry in sensitivity between its radio astronomy stations and those of the other services. Unlicensed devices could receive a permissive control signal well away from the radio astronomy station and proceed to broadcast at levels which are detrimental to the radio astronomy service. Alternatively, they could move out of range of a "stop" signal at separation distances too small to prevent interference detrimental to operations of the radio astronomy service. Outfitting the NRQZ or other quiet and coordination zones around radio astronomy stations with control-signal broadcasting stations strong enough to guarantee reception by all unlicensed devices seems paradoxical because it places an added burden on the spectrum precisely where such burden should be avoided.

18. Consistent with our comments in the Cognitive Radio proceeding, the NRAO notes that the National Radio Quiet Zone and the various coordination zones around registered radio astronomy stations are well-defined and quite regular. It would be a simple application of the Commission's required smart-radio technology to control operation of smart unlicensed devices within radio astronomy coordination/quiet zones using available GPS technology.

19. It seems likely that the typical consumer/user of an unlicensed low-power personal/portable device will, in the absence of evidence to the contrary, expect that any device bearing a certification sticker is fundamentally harmless. This user might be somewhat incredulous if informed by an ordinary-appearing agent of the radio astronomy service that his personal electronics kit was believed to be ruining a scientific experiment at a distant, unseen and otherwise unknown radio astronomy installation. However, it seems likely that end-users would be inclined to act responsibly if they had previously been made aware of the potential for harmful interference which is inherent when such devices were operated in especially sensitive areas.

20. Therefore, the NRAO requests that the Commission require the manufacturer or vendor of such personal/portable devices to provide for the end-user a statement of the conditions under which such devices must operate,

conveying in the clearest terms possible the impermissibility of causing harmful interference and the possible undesirable consequences of operating such devices near radio astronomy stations, particularly within the National Radio Quiet Zone. The statement should at least describe a representative sample of stations which are likely to be affected, with their geographic coordinates, along with other helpful information. One such list (US radio astronomy stations operating at 608-614 MHz) is given as Appendix A of this document.

VII. Remediating Harmful Interference Generated by Unlicensed Personal/Portable Devices

21. The NRAO believes that proper notification will aid in efforts to maintain the health of the electromagnetic environment at its stations but remains wary of allowing unlicensed personal/portable uses of frequencies which, as the Commission rightly notes (NPRM at 7) have such "favorable propagation characteristics" and which are subject to coordination requirements in licensed uses (albeit at much higher eirp).

22. When harmful interference occurs between licensed services, the course of remediation efforts is usually clear from the regulatory framework. For harmful interference to radio astronomy stations caused by the unlicensed personal/portable devices considered in the present proposed rule making, encounters involving harmful interference are likely to be somewhat transient. Thus, the usual notification processes to the Commission from the victim, and from the Commission to the transgressor (see the NPRM at 41), are likely to prove ineffective in individual instances. They might prove efficacious if some types or brands of devices proved consistently troublesome.

23. NRAO therefore requests that personal/portable devices not be permitted to work in the National Radio Quiet Zone, or in coordination zones about other radio astronomy stations. As noted above, NRAO favors the use of available GPS signals, incorporated within *smart radio* technology, to effect such control.

VIII. Summary of Concerns and Recommendations

24. NRAO strongly endorses the Commission's proposal not to allow unlicensed use of channel 37, which coincides with the protected radio astronomy band at 608-614 MHz.

25. Use of the protected 608-614 MHz band would be greatly aided if the adjacent channels 36 and 38 were not assigned to unlicensed devices, at least near stations of the radio astronomy service. This would be consistent with the current practice not to assign broadcast licenses to these channels near radio astronomy stations, respecting the coordination distances for adjacent channels which are fundamental to the rules presently governing the broadcast TV service.

26. The protected radio astronomy band centered near 74 MHz is likewise situated within a continuous band assigned to the broadcast service. Noting that the Commission has already proposed not to permit unlicensed use of the channel 4 band, which we most strongly endorse, the prospects for continued use of the 74 MHz band would be greatly enhanced if the spectrum occupied by channel 5 were not assigned to unlicensed devices. As discussed here (see para. 8), the channel 5 spectrum also has some unfortunate harmonic coincidences with protected radio astronomy bands, making unlicensed use of channel 5 spectrum unsuitable near radio astronomy stations.

27. As detailed at 8 here, there are a substantial number of unfortunate coincidences between low-order harmonics of spectrum within bands assigned to channels 5, 6, 11, 12, 14, 27, 28, 47, 48, 52, 53, and 54 with protected radio astronomy bands; also, channels 4, 5, 36, and 38 abut protected radio astronomy bands. Continued protection of the radio astronomy bands suggests that these channels should not be assigned to unlicensed devices, especially

personal/portable devices, and should not be used in the National Radio Quiet Zone or in coordination zones about other radio astronomy stations.

28. The NRAO asks that unlicensed devices in the fixed/access category be required to coordinate with radio astronomy stations in the same way as licensed users of the broadcast spectrum. It strongly endorses the Commission's proposal to require registration of such devices.

29. The NRAO asks that personal/portable devices be required to incorporate *smart-radio* technology based in GPS location-sensing such that their operation would be precluded in the National Radio Quiet Zone.

30. Operation of personal/portable devices in the spectrum now assigned to channels 5, 6, 11, 12, 14, 27, 28, 36, 38, 47, 48, 52, 53 and 54 should not be permitted in coordination zones around radio astronomy stations because these bands are particularly likely to cause harmful interference.


31. The NRAO suggests that an outreach effort be undertaken to inform all end-users of personal/portable unlicensed devices of the particular responsibilities which accrue to use of such devices in sensitive areas. In particular, we suggest that the sale of such devices should be accompanied by informational material concerning the unacceptability of harmful interference and the liabilities of using unlicensed devices in sensitive areas. Details of such sensitive areas, including locations of radio astronomy stations, the National Radio Quiet Zone, etc. should be included.

Respectfully submitted,

National Radio Astronomy Observatory

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Appendix A.

US RADIO OBSERVATORIES OBSERVING
AT 608-614 MHz

OBSERVATORY	LONGITUDE ° ' "	LATITUDE ° ' "	ELEV. m	Point of Contact
Allen Telescope Array	W 121 28 24	N40 49 04	1043	Dr. Mike Davis Phone: 650 960 4556 E-mail: mdavis@seti.org or Dr. Geoffrey Bower Phone: 510 642 4075 E-mail: gbower@astro.berkeley.edu
Arecibo Obs.	W 66 45 11	N18 20 46	496	Dr. Murray Lewis Phone: 787 878 2612 ext. 285 E-mail: blewis@naic.edu
Green Bank Telescope (GBT)	W 79 50 24	N38 25 59	825	Mr. Wes Sizemore Phone: 304 456-2107 E-mail: wsizemor@nrao.edu
Very Large Array (VLA)	W107 37 04	N34 04 44	2126	Dr. Mark McKinnon (see below)
Very Long Baseline Array (VLBA) Stations:				Dr. Mark McKinnon Phone: 505-835-7273 E-mail: mmckinno@nrao.edu
Pie Town, AZ	W108 07 07	N34 18 04	2371	
Kitt Peak, AZ	W111 36 42	N31 57 22	1916	
Los Alamos, NM	W106 14 42	N35 46 30	1967	
Ft. Davis, TX	W103 56 39	N30 38 06	1615	
N. Liberty, IA	W 91 34 26	N41 46 17	241	
Brewster, WA	W119 40 55	N48 07 53	255	
Owens Valley, CA	W118 16 34	N37 13 54	1207	
St. Croix, VI	W 64 35 03	N17 45 31	16	
Hancock, NH	W 71 59 12	N42 56 01	309	
Mauna Kea, HI	W155 27 29	N19 48 16	3720	